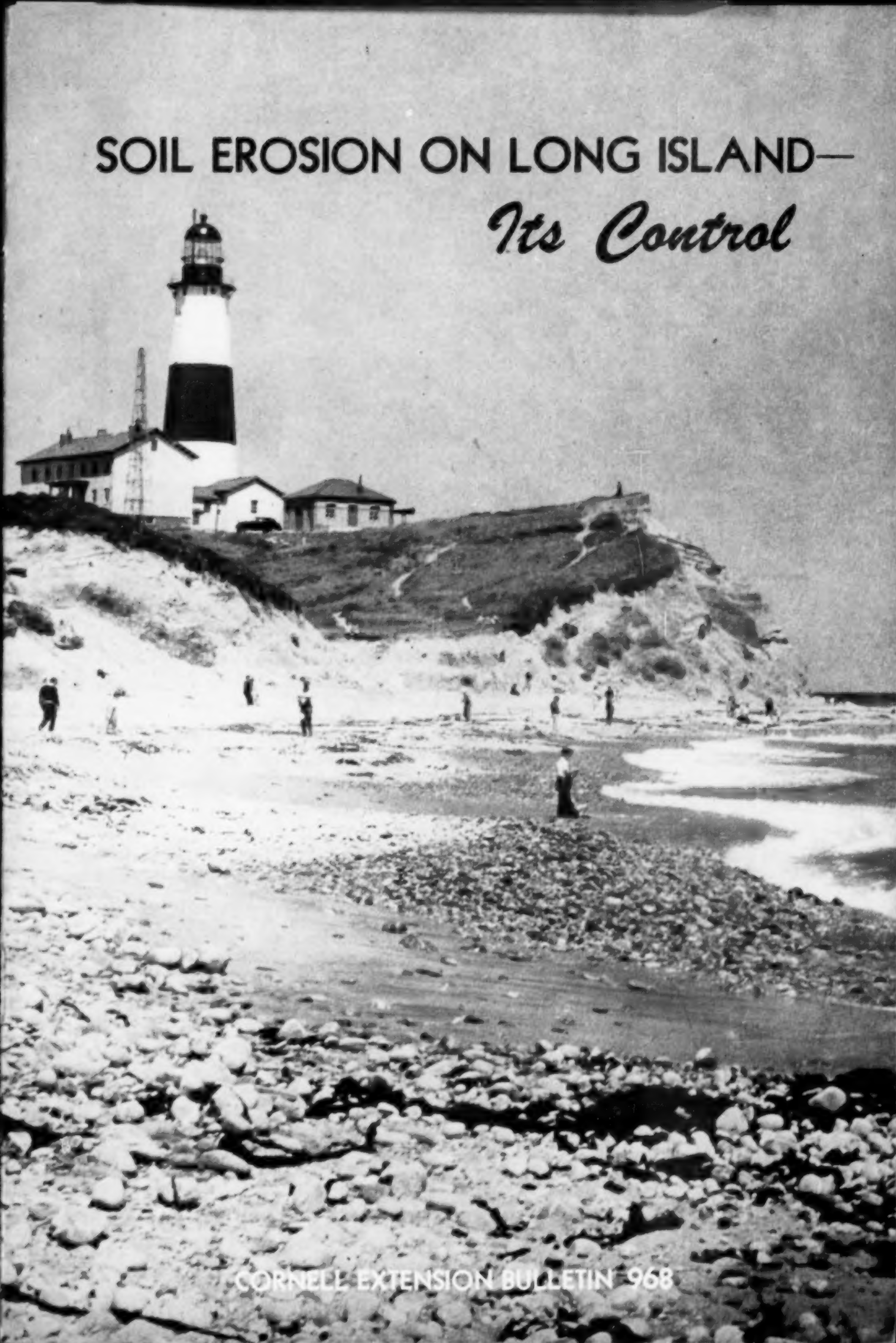
SOIL EROSION ON LONG ISLAND—
Its Control



CORNELL EXTENSION BULLETIN 968

Contents

Soil Erosion on Long Island—Its Control

George Free, Carl Winkelblech, Hugh Wilson[1]

Soil erosion on Long Island, as elsewhere, is an indication that agricultural practices are not completely in balance with the natural forces acting on the land. Each erosion problem requires the consideration of soil limitations, of potential and existing cultural practices, and of the economic aspects of alternative corrective measures. This bulletin calls attention to the conditions that accelerate erosion on Long Island and presents in a general way some methods that reduce it. It is a complete revision of Cornell Extension Bulletin 744, by A. F. Gustafson, John Lamb, Jr., and Hugh M. Wilson, published in 1940.

CONDITIONS

Size and Location

Long Island is 120 miles long and has an average width of 20 miles. It is the biggest island on the United States Atlantic seaboard. Proximity to New York City makes the farm land valuable not only for crop production but also for industrial and residential developments. As a result, land values are high.

Geology, Topography, Soils, and Climate

The glacial period, which covered with ice most of what is now New York State, made Long Island soils and topography as one sees them today. The hills along the north shore and the other hilly areas are moraine deposits that mark the farthest advance of the ice front. Gently rolling and nearly flat areas are made up of outwash materials which were carried to their present location by torrential streams that flowed from the melting glacier. Ice cakes, which later melted, are believed to have left the kettle holes that dot the landscape. In general, the slope is to the south and averages about 20 feet per mile.

Underlying soil materials are, as compared with those of most of the United States, remarkably deep. At

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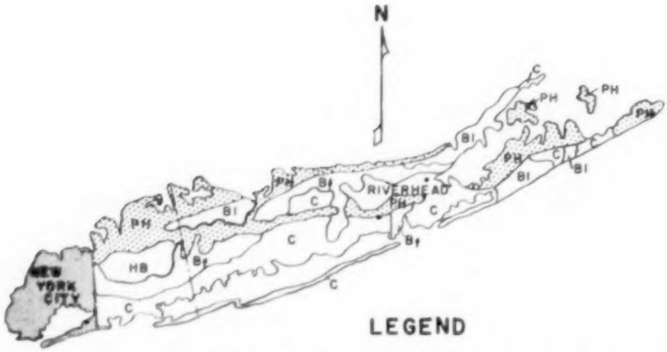


LEGEND

WELL TO EXCESSIVELY DRAINED NEARLY LEVEL SOILS
C — COLTON AND ADAMS ASSOCIATION

SOMEWHAT EXCESSIVELY DRAINED HILLY SOILS
PH - PLYMOUTH-HAVEN ASSOCIATION

WELL-DRAINED NEARLY LEVEL SOILS
B_f - BRIDGEHAMPTON FINE SANDY LOAM ASSOCIATION
BI - BRIDGEHAMPTON LOAM ASSOCIATION
HB - HEMPSTEAD-BRIDGEHAMPTON ASSOCIATION

Figure 1. Size and distribution of main soil areas on Long Island

Huntington in the western end of the island, bedrock is about 700 feet below the surface; while in the eastern portion, probably 2500 feet of alternate layers of fine and coarse materials cover the rock. This provides excellent storage for underground water and explains the scarcity of surface streams. Nevertheless, some of the surface soils are exceedingly drouthy.

Surface soils vary from coarse gravels to fine sands and silt loams. The size and distribution of the main soil areas are shown in figure 1. Within these areas, however, are sizable blocks of other soil types.[2]

Soils are derived from granitic materials which are naturally low in fertility but are easy to work and, except for the coarser textured soils, are responsive to good management and fertilization. The capacity to store and supply water for crops is the principal condition that determines each soil's agricultural value. Roughly, about one-half of the soils are of such low water-holding capacity that they are essentially non-agricultural,

[2]Further information on soils is given in Cornell Extension Bulletin 930, *Soils and Soil Associations of New York*, by Marlin W. Cline.

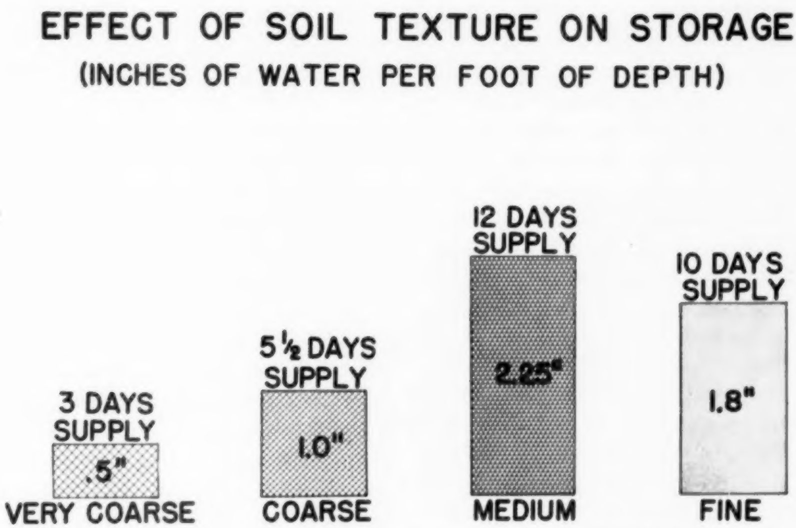


Figure 2. Available moisture-holding capacity of soils by textural classes

one-fourth are somewhat drouthy, and one-fourth are well suited to intensive agriculture.

Average annual precipitation ranges from 45 to 50 inches, which represents an average of 2,000,000 gallons of water per square mile per day. In spite of the high rainfall rate, growing crops frequently suffer from lack of water. This is due to: a combination of imperfect rainfall distribution, soil characteristics, shallow-rooted crops, and high wind velocities which increase evaporation. Since temperatures are influenced by the ocean, the winters are mild, the summers are seldom hot, and the area has a frost-free period of from 170 to 190 days. Although the ground freezes in winter, frost penetration is seldom deep and snow lays on the ground for only a comparatively short time. High wind velocity at certain seasons, due to the exposed position of the island, causes severe wind erosion and damage to plants. Since the island lies in the path of tropical hurricanes, excessive damage from wind, waves, and torrential rain is all too frequent.

Agriculture

The first white settlers landed at Southold and Southampton in 1640. As in other pioneer settlements, subsistence farming was the rule during the early days. Later, a generalized type of farming developed which included livestock production. In the latter part of the nineteenth century, as cities began to

grow rapidly in size, there was a trend away from livestock towards more intensive production of potatoes and vegetables. Except for ducks and poultry, which are produced under a factory rather than a farm system, livestock numbers have continued to decrease. In 1954, nearly 62,000 acres were used for the production of potatoes, vegetables, and fruit. Less than 4 percent of the cropland was in hay. Prior to 1910, much of the fertilizer was applied in the form of manure which was shipped from New York City. As automobiles took the place of horses, the supply of manure decreased, until, at present, practically all of the added plant food in the soil is supplied in the form of mineral fertilizer. Although duck and poultry manures are available, sometimes for the cost of hauling, most farmers do not feel them worthwhile. Consequently, on many farms, crop residue and winter cover crops provide the only source of organic matter.

HAZARDS

Erodibility of Soils

The water erodibility of a bare soil, or *potential* erosion, as contrasted with *actual* erosion, is determined largely by three soil characteristics:

1. The ease with which the small individual units of soil can be detached or separated from their neighbors by falling rain or flowing water.
2. The ease of transportation, that is, the detached particles are relatively large and dense like sand or gravel, or smaller and more easily moved like silt, clay, and bits of organic matter.
3. The ability of the soil to absorb and transmit water to depths within the profile, which determines the proportion of water tending to flow over the surface.

This brief discussion of a complex subject sets the stage for an important question. How does the water erodibility of a typical bare cropland soil on Long Island compare with that of other bare soils, assuming slope, moisture, and rainfall are the same?

Samples from the plow layer of soil at the Vegetable Research Farm near Riverhead have been compared with samples of Honeoye soil, an important soil upstate, and found to be about four times as erodible[3]. Honeoye has a medium rating in a study involving several soils over the country[4]. Thus, the soil at the Research Farm is highly erodible, where slope, rainfall, and lack of cover permit soil movement. One important reason for the difference between the two soils is that the structure of the Honeoye is more crumb-like. Furthermore,

[3]Unpublished data.

[4]*The Quantitative Evaluation of Factors in Water Erosion—A First Approximation.* By G. W. Musgrave. Jour. Soil and Water Cons. **2**:137. 1947.

the crumbs tend to be more stable under the disintegrating influence of rain than those in the sample of Long Island soil. Under cropland conditions, the plow layer of Honeoye weighs about 70 pounds per cubic foot as compared with 90 pounds for the Long Island soil. This shows that the Long Island soil is more dense.

Wind erodibility of a smooth, bare soil is largely determined by the moisture content and by particle size. Only dry soils are moved, and erodibility is in proportion to the percentage of particles less than $\frac{1}{32}$ inch in diameter[5]. This is near the upper size limit of what is classed as *coarse sand*.

Fine dust may be carried high into the air and over long distances. Much of the soil movement by wind is, however, near the ground, and in a series of bounces called *saltation*. The actual amount of wind erosion on a given soil may be great or slight depending upon wind velocity, moisture, roughness, ground cover, and the like.

Erosion, whether the active agent is water or wind, tends to be selective in removal. Organic debris and the finer particles are more easily transported than the coarse materials.

Climate

Possibly the best way to evaluate Long Island climatic hazards is to define conditions that should keep wind and water erosion at a minimum and then to compare this ideal with the actual.

Ideally, wind should provide air drainage, but never reach gale proportions. Rain should be adequate for crops and yet gentle and well distributed with respect to needs. If there is to be snow and freezing temperatures, the snow should be deep enough to blanket and insulate the soil. This would minimize the hardness and depth of soil freezing, and thus contribute to absorption of water whether from melting snow or from rain.

It should be apparent by now that Long Island climate, however attractive it is for many purposes, does present definite erosion hazards. Montauk, at the eastern end of Long Island, has the distinction of having a greater total wind movement and a greater number of separate winds of more than 50 miles an hour velocity than other points along the Atlantic coast[6]. The greatest number of these winds usually are during the period from December through March, with June and July relatively free from them. Fortunately, both total movement and maximum velocities are less at locations away from the eastern tip.

Water needed for evaporation and for best crop growth during

[5] *Estimates of Wind Erodibility of Field Surfaces*. By W. S. Chepel and W. P. Woodruff. Jour. Soil and Water Cons. **9**:257. 1954.

[6] *The Climate of Long Island*. By Norman Taylor. Cornell Univ. Agr. Exp. Sta. Bul. 458. 1927. (Out of print.)

Figure 3. Supplemental irrigation on Long Island. This type of irrigation is widely used on the Island

the summer tends to average about 0.18 inch per day. In 1954, the average amount of rain per day from May 22 through June and July was less than 0.05 inch. During August and September, the same year, the average amount per day was about 0.35 inch, because of hurricane contributions. Both deficits and excesses are rather frequent.

Supplemental irrigation effectively takes care of the droughts, but excesses in rain intensities and amounts are other considerations. Nearly 6.5 inches fell in less than 24 hours at the Vegetable Research Farm on September 10 and 11, 1954, with more than 2 inches in only two hours. An example of high-intensity rainfall of the thundershower type is the storm of August 21 and 22, 1952. Nearly 1 inch fell in fifteen minutes.

Excessive Erosion

Fresh evidence of water-erosion damage, unless it reaches the flood and gully stage, may be obliterated by normal plowing and seedbed preparation. The cumulative effects of soil losses from sloping land, however, are serious. Removal of fine productive surface soil decreases the moisture-holding capacity of the profile. The loss of fine soil and organic matter makes problems such as crusting, compaction, and reduced water intake more and more serious. In fact, excessive erosion increases the tendency for erosion to recur, at least until more resistant material is exposed.

Losses of topsoil in certain areas result from sales of sod and nursery stock where some amount of soil goes along with the product sold. While the agent of removal in

Figure 4. Scour and deposition in cropland channel near Bridgehampton, caused by flood flow during 1954 hurricane

Figure 5. Fresh evidence of serious erosion on sloping cropland. Rills and shallow gullies may be obliterated by plowing, but the effect of soil removal remains

Figure 6. A "kettle-hole," or natural water-disposal and absorption area. Silting and the removal of brush from such areas decrease their effectiveness

Figure 7. Potato rows may be long and sloping. This field has just been cultivated

these situations is neither wind nor water, the result may be the same.

The great depth of soil materials on Long Island has been previously mentioned. The depth of the soil mantle itself, however, down to the underlying substrata of loose coarse sand and gravel, is not great even where there has been little erosion. Nearly half of the detailed borings on a nearly level 20-acre tract of loam and sandy loam soil near the Vegetable Research Farm at Riverhead showed depths of 24 inches or less and less than one-third showed depths greater than 30 inches.

Stream Channels and Water-disposal Areas

When soil freezes and snow melts or rains occur, the runoff and erosion hazards are great. Because of the general lack of stream channels and other convenient disposal areas, water may flow on the surface for miles if the soil is near saturation or is frozen. Silting of "kettle-holes" and the removal of wood and brush which insulated the soil against freezing in such areas have undoubtedly meant a loss or decrease in the effectiveness of some natural absorption and disposal areas.

Type of Farming

The prevailing type of farming on Long Island—a natural consequence of favorable soils, proximity to markets, water for irrigation, and high land values—is in itself a definite erosion hazard. Cover is the best protection against erosion, and potatoes and other row crops are classified as soil-exposing, rather than soil-protecting, crops. Furthermore, these crops usually

Figure 8. Cropping extending into right-of-way along public road. This practice eliminates road ditches and sodded absorption areas. Many fields slope towards the road, and the soil and water flowing into the highway may create a safety hazard

extend onto the right-of-way along public roads, and the hard surface is used as a turn-strip. This eliminates both sodded absorption areas and road ditches.

Grasses and legumes for hay or pasture are definitely soil-protecting and soil-improving crops and are invaluable aids in the control of runoff and erosion, but farmers generally feel that in terms of either needs or economic considerations, sod crops have little value in Long Island rotations. There are few dairy farms on Long Island, and horses except for recreational purposes have long since been displaced by the tractor and the automobile.

Soil Compaction

Soil compaction contributes to the difficulty of controlling erosion and runoff on Long Island. Any loose soil is compacted by traffic. This automatically reduces the ability to take in and to transmit water. It may at the same time increase depth of frost penetration.

Some degree of compaction is unavoidable, and perhaps even desirable. The kind of compaction *not*

Figure 9. Traffic on cropland cannot be eliminated. Here potatoes are being planted. Other operations involving traffic are cultivating, spraying, and harvesting. Note "bald spots" caused by erosion on slope in background

needed in cropland soils, however, is the kind engineers try to achieve when constructing a road, a runway, or an earth dam. Man-made compaction that limits the rate of water movement and the penetration of plant roots can be found in many Long Island soils both within and below plow depth. Anyone who doubts this should observe the difference between rates of water intake in "wheel" rows and "nonwheel" rows. Rain, irrigation water, or even a pail of water can be used for such a test.

Some compacting forces can and do reach below plow depth when there is no ridging. When, however, crops such as potatoes are ridged, these forces are applied to the subsoil. Shifts in location of the traffic as rows are moved from year to year result in a rather uniform layer of compacted soil about 4 to 8 inches thick just below plow depth. This is commonly called a *plow sole* or *plow pan*. *Traffic sole* would be a better term. A study of tractor traffic involved in potato production showed 25 miles per acre each year[7]. This did not include traffic from trailed equipment, such as planters and sprayers.

The percolation or water-transmitting rate for some soil samples taken at a 10- to 13-inch depth from the compacted layer under potatoes was only 0.01 inch per hour, as compared with 0.10 inch for the 19- to 21-inch depth in the same area, or 0.35 inch at the 10- to 13-inch depth under woods. Soil textures were the same for all samples. The compacted layer constitutes a real bottleneck in terms of water movement in the soil profile.

For any given soil and compacting force, there is a moisture content at which maximum compaction occurs. For the forces involved, this is near what is called *field capacity*, meaning that moisture content that is reached about one or two days after a soaking rain or after irrigation. The degree of compaction increases as soil organic matter decreases[8]. Also, as the forces increase or the compactibility of the soil decreases, compaction tends to be maximum at lower and lower moisture contents. The permanence of the compaction, if the soil is not mechanically disturbed, depends upon the soil characteristics, including organic matter, type of clay, and environmental conditions including moisture, roots, and biological activity.

Another kind of compaction that often causes difficulty is that at the soil surface where it is more commonly called *crusting*. These seals,

[7] *Traffic Soles.* By G. R. Free. Agr. Engr. **34**:528. 1953.

[8] *Compactibility of Certain Soils as Related to Organic Matter and Erosion.* By G. R. Free, J. Lamb, and E. A. Carleton. Jour. Amer. Soc. Agron. **39**:1068. 1947.

Further Studies on the Effect of Longtime Organic Matter Additions on the Physical Properties of Sassafras Silt Loam. By M. B. Russell, A. Klute, and W. C. Jacob. Soil Sci. Soc. Amer. Proc. **16**:156. 1952.

or crusts, can reduce the rate of water intake to one-fourth or less that of soil without the crust. Raindrop impact on bare soil is to a large extent the cause for this kind of compaction.

CONTROL

Control of Water Erosion

Ways to control water erosion fall into two classes: (1) those that keep water where it falls, and (2) those that remove excess water safely. On a field, farm, or community basis, usually a combination of methods must be selected to meet the specific situation.

Keeping water where it falls

Some of the soil and crop-management practices already widely followed are basic steps in an erosion-control program. Examples are the liberal use of fertilizer and the planting of winter cover crops. Another example is the practice of combining a certain amount of clod-breaking and smoothing with the plowing operation. This eliminates some traffic in seedbed preparation and also reduces manipulation of the soil.

Permeability

Usually, anything that tends to produce or maintain a high rate of water intake and a moderately high rate of permeability in the soil profile is desirable.

Excessive compaction, if present, should be removed by a mechanical operation, such as chiselling or some form of deep plowing that leaves the subsoil in place. Chiselling should be across the slope, and care should be taken that conditions are such that more compaction is removed than is caused by the operation itself.

Loosening of a compact layer in May by tandem double-cut plowing persisted to a marked degree under potatoes in a test at Riverhead in 1953, except where fresh traffic in wheel middles caused reconsolidation. Based on measurements made the following October, the permeability and the amount of roots in the layer just below ordinary plow depth were increased by 20 percent, and 35 percent respectively[9]. This indicates an appreciable change in compaction status and, over a period of time, the addition of organic matter in the form of roots should also be beneficial.

Careful avoidance of excess traffic and loads, particularly at times when soil moisture is high and there is no cushioning layer of surface soil covering the subsoil, should help to solve the compaction problem.

Surface intake

The rate of intake of water is important, particularly for the smaller high intensity storms and for irrigation. Rate of movement within the profile, however, may limit intake of water during the

[9]Unpublished data.

larger storms and even during those of moderate size which occur when the upper soil layers are saturated from previous rainfall or irrigation. Also, water may enter the profile, flow along beneath the surface on a compact layer, and seep out to the surface again down the slope.

The intake of water at the soil surface is promoted by anything that tends to stabilize the loose crumby structure of soil resulting from plowing or cultivation. Residues on the surface, growing crops, and cover crops provide protection, and at the same time contribute organic matter. This helps to stabilize the soil crumbs or aggregates against slaking or breaking down under raindrop impact. As an example of this effect of organic matter, it was found that soil crumbs in an experiment at Riverhead were 41 percent water stable where additions of fertilizer and manure had been made over a period of years, and only 29 percent water stable where no manure had been used[10]. Corresponding values for soil organic matter were 3.9 percent and 2.8 percent, respectively. This was under continuous cropping to vegetables. Manure is not usually available, but the results are cited to illustrate the beneficial effects of organic matter in general.

Some of the new chemical soil conditioners can improve certain physical properties of many soils, when improvement is needed, much more rapidly than organic matter. Cost at present, however, limits their use to special situations and relatively small areas.

[10]*Physical Properties of Sassafras Silt Loam as Affected by Long-time Organic Matter Additions.* By A. Clute and W. C. Jacob. Soil Sci. Soc. Amer. Proc. **14**:24. 1949.

Rotations

More use of grain and sod crops in rotations would help greatly to control erosion. Benefits from increased soil protection and decreased velocity of runoff under such covers would be realized immediately. From the long-term standpoint, there would ultimately be less cultivation and traffic and probably greater contributions to soil organic matter and structure. Under Long Island conditions, however, it is easy to understand why hay, pasture, and small grains —mostly wheat and rye—account for only 19 percent of the harvested acreage.

Cover crops

In cover-crop management, one of the difficulties many times is that of late seeding. The general practice is to fertilize the main crop and depend upon the cover crop being adequately fertilized by the residual plant food left in the soil. There are times and conditions where additional fertilizer for the cover crop itself is warranted to insure maximum growth and vigor. The storage of plant food in the above- and below-ground growth of cover crops reduces leaching losses and provides a controlled

Figure 10. Drilled rye for winter cover. Differences in cover, such as those seen on the left and on the right of the photograph, can result from late or early seeding and inadequate or adequate fertilization

release of plant food to the growing crop as the residues decompose.

It is evident that the ordinary procedures of soil and crop management can be manipulated to alter the erosion characteristics of a given soil situation. What else can be done?

Contour and terracing

One of the basic principles of controlling runoff and erosion is to make it more difficult for temporary excesses of water to escape. Rows that extend up and down even gentle slopes have little storage capacity, and allow little time for excess water to be absorbed. The velocities of flowing water are likely to be at an erosive level. Contouring is an excellent basic control practice. A slight, continuous grade, rather than exact contouring is recommended under compact or off-drainage soil conditions.

Terraces also have a contribution to make in the control of runoff and erosion. They may be regarded as safety or emergency valves to make excess water "walk off" *across* the slope, rather than "run off" *down* the slope. They are usually cropped, and hence should be broad with gentle back slopes. Size and spacing depend upon soil, slope, and cover. Maintenance and the removal of silt reaching the channel can usually be accom-

Figure 11. Potato rows near the contour. A controlled or reduced row grade helps to keep water where it falls

plished during plowing operations. There must be provision for safe disposition of the water.

The methods of control discussed thus far are primarily concerned with controlling sheet and rill erosion rather than that resulting from the larger concentrations of water. Too often the success or failure of practices in the control

Figure 12. A cropland terrace protected by a rye cover crop. Line indicates the position of the channel, ridge, and backslope. Terraces allow water to "walk-off" to areas of safe disposal

of sheet erosion is judged by its immediate effect on crop yields. There are no long-time plot studies on Long Island to show the effect of erosion control on crop yields. Results, however, are likely to be similar to those measured on an upstate soil as shown in figure 13. The long-time benefit from keeping soil, water, and plant nutrients in place is seen to be marked and worthwhile. Control on an individual field basis also leaves less water and silt to handle in concentrations.

Removing excess surface water

Even though the best known methods are followed in keeping water where it falls and using cultural practices that encourage rapid infiltration, under certain conditions surface runoff is inevitable. The cropping practices on Long Island are such that large areas of soil are bare during a part of the year. In addition, more than 90 percent of the rain that falls on hard-surface roads finds its way into adjacent crop fields, usually this discharge is concentrated in low areas. The highly erodible nature of the soil makes it necessary to provide for the conveyance and disposal of surface runoff in a manner that will protect and stabilize valuable crop land. This means that certain areas should be kept out of the usual cropping system and planted to erosion-resistant grasses or be occupied by struc-

Figure 13. Trend of yield benefits resulting from erosion control by contouring on Honeoye soil—plots 100 feet long on a 10 percent slope. In a relatively short time differences in yields between contour and up-and-downhill plowing and planting of various crops rather consistently range from 20 to 30 percent. Rotations and fertilization have been identical for both sets of plots. Keeping soil, water, and plant nutrients in place pays excellent dividends

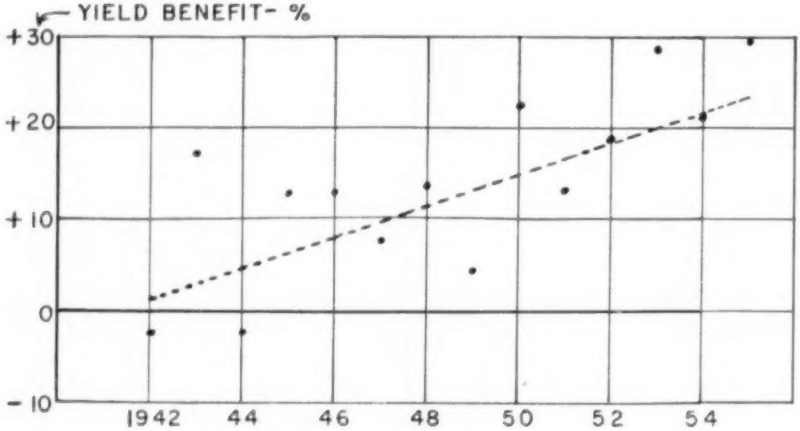


Figure 14. A natural drainage way protected by permanent cover

tures designed to retard peak runoff. Several methods of handling surface water are described in the following paragraphs.

Outlet channels

The natural drainage ways or depressions can be seeded to a permanent grass cover and maintained without much additional shaping or grading unless the depressions show signs of previous gullying. Drainage ways that are gullied or have abrupt changes in grade, as on farm boundaries, should be reshaped to keep the velocity of water as low as possible. Wide flat channels tend to spread the flowing water over a large area and thus reduce its speed and cutting power. The actual size and shape of outlet channels is related to the natural slope of the area and the amount of water they must handle. Where large drainage areas or difficult erosion problems are involved, the recommendations of an experienced conservationist should be followed in establishing permanent outlet channels. On less complicated projects, wide and shallow channels with a uniform grade can be prepared with ordinary farm equipment. These outlets are an integral part of a sound land-management program and deserve the same degree of treatment and management as the more productive acres. Properly installed, they can be used as turning areas for farm equipment.

Diversion channels

Diversion channels, as distinguished from natural outlets, are constructed to carry excess water

from the area of accumulation by some unnatural route to another area for safe disposal. They are built on either a uniform or a variable grade across the slope. They intercept runoff water from higher elevations and thus protect the lower lying lands from floods and erosion. Diversion channels must be built to carry the designed flood flow at a safe velocity. Overtopping and excessive channel velocities could cause serious damage under Long Island conditions. Concentration of water is always dangerous, but it is especially so on highly erodible soils. In addition to building diversion channels of adequate capacity, the berm, channel, and a 30-foot filter strip above the channel should be seeded and maintained in permanent grass cover. The diversion must also outlet into a safe disposal area such as woodlot, natural stream channel, "kettle hole", or prepared outlet.

Wooded areas on Long Island are known to absorb water at a very high rate and are able to handle, within reasonable limits, the additional water discharged into them from diversion channels.

Natural depressions

Natural "kettle holes" can be used as temporary storages and as a means of getting water into the soil. In many situations the capacity and rate of infiltration have been reduced by an accumulation of fine soil particles on the bottom.

These natural depressions, where they can be used, offer a low-cost method of water disposal if the silt is removed periodically from the bottom.

Dug seepage pits

Seepage pits have been dug on many farms and by several municipalities to dispose of excess surface runoff in areas where natural holes do not exist. These "man-made" pits, like the natural depressions, need to be cleaned of silt accumulation at frequent intervals for rapid percolation. The depth of these pits is governed by the thickness of the sand and silt above the permeable gravel layer. Test holes may be dug to determine this depth before the construction of a large pit is undertaken. The capacity of seepage pits should be related to the amount of runoff from the watershed. As a guide, from 200 to 300 cubic yards of storage capacity should be provided for each acre of drainage area. A seepage pit that is not cleaned frequently can become a muddy pond with no runoff control value and may be a safety hazard.

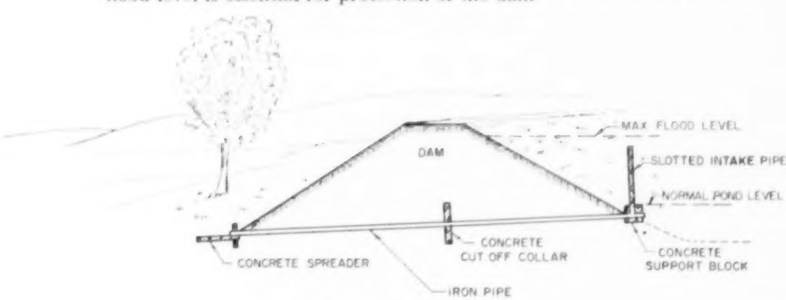
Retention dams

Retention dams or reservoirs would contribute much to the improvement of runoff problems in areas with rolling topography suitable for dam construction. They can sometimes be built at a lower cost than seepage pits of the same capacity and, if properly construct-

Figure 15. A dug-out drainage basin or seepage pit near Bridgehampton. Such pits should have adequate capacity, and accumulated silt should be removed periodically

ed, should require less frequent maintenance. Flood-retention dams should be designed to hold about 3 inches of water from each acre of the watershed above them. They must have a properly designed pipe outlet to regulate the flow from the reservoir and an emergency spillway to pass flood flow. The spillway is important as a pro-

Figure 16. Typical cross-section of a retention dam. In addition to the drain which provides controlled release of water, an emergency spillway at maximum flood level is essential for protection of the dam



PROFILE OF DAM AT CENTER LINE

tection for the dike. This type of structure is designed to reduce the peak flow to the extent that control will be less difficult at some lower point in the watershed. Retention dams should be designed by an experienced engineer to insure that the structure has adequate capacity to accommodate major flood conditions without overtopping. According to Section 948 of the Conservation Law and Amendments thereto, it is necessary *under certain conditions* to have plans for reservoirs and dams approved by the New York State Department of Public Works, or for a notice to be given the State Superintendent of Public Works, prior to construction by the person supervising the work, who may be any licensed professional engineer or an engineer employed by an agency cooperating with a soil conservation district. Such legal responsibilities apply only when the drainage area, height of dam, pond capacity, or slope of spillway exceed specified limits. This section of the law was enacted to protect the public against damage due to faulty design and construction. Fences enclosing the pond area and "No Trespassing" signs are desirable from the standpoint of other hazards and personal liability and may be required by local ordinances in some areas.

Although some of the retained water would seep into the ground water table, most of it would be released at a controlled rate. Retention dams can be built in steep-sided depressions which are seldom used for row crops. Maintenance of these structures includes a good sod cover on the dike and spillway, and cleaning the bottom of the pond when silt deposits begin to interfere with the drain inlet.

Highway runoff

Highway runoff is an important contributor to the erosion problem on Long Island. Many of the older roads were laid out before the land was cleared extensively and before surface runoff became a serious problem. These roads now act as outlet channels for surface water. Their grade is seldom continuous to a defined stream channel or safe outlet so they frequently accumulate large quantities of water and discharge it into cultivated fields. During flood periods, the roads can become hazardous and impassable. There was probably little need for side ditches along the early roads since the lower quantity of runoff water readily percolated into the adjacent soils, but today the need for sod-covered side ditches is apparent. The side ditches not only provide drainage for the road surface but also act as an additional absorption area along the highways. It is common practice for land owners to plow the right-of-way and use the hard surface road as a turn strip. Since most of the adjacent land is in continuous row crops, there is no opportunity for

sod to become established on road shoulders. This practice is a traffic hazard; it is detrimental to the surface of the road; and contributes to the wind and water erosion problem on adjacent cropland.

Watershed approach to erosion control

Surface water is no respecter of property boundaries. As it flows from the top to the bottom of a watershed, its destructive power increases greatly. Sometimes it is possible and often necessary for land owners within a watershed to join together in the control of runoff for the mutual benefit of everyone. A brief discussion of a proposed plan for a small watershed near Bridgehampton may illustrate the types of control that are possible and the extent to which cooperation, both public and private, is needed to make the plan effective.

The Bridgehampton watershed lies in the general area of Butter Lane, Lumber Lane, and Scuttlehold Road. It includes about 620 acres of land, of which approximately 11 acres are in woods, 23 acres are in homes and farmsteads, 28 acres are idle, 11 acres are in paved roads, and 547 acres are tilled cropland. Although paved roads account for less than 2 per cent of the total watershed area, they contribute about 7 percent of the flood runoff. The entire watershed has an average slope of less than 1 percent, but a few small areas have slopes up to 15 percent. It is bounded on the northeast and southwest by rough, broken land covered with scrub oak and other forest trees. Potatoes are grown almost exclusively on the tilled acreage. Rye is used as a winter cover crop. Steep slopes within the watershed show signs of severe sheet and gully erosion to the extent that some areas have lost all of the original topsoil and potato yields have been low. Near the lower end of the watershed, runoff has caused serious erosion, deposition, and flood damage to cropland, private dwellings, and public transportation facilities. The highways act as waterways to concentrate and discharge water into unprotected areas.

A detailed survey of the entire watershed indicated that a threefold approach would be effective in reducing by about 75 percent the runoff to be expected from a 50-year frequency rainfall if a cooperative approach was followed.

First, agronomic and tillage practices were considered that might hold water in place long enough for more of it to be absorbed. Several areas were found where contour tillage appeared practical. There was evidence that subsoil chisels should be operated across the general slope rather than parallel with it. A longer rotation, including one or more years of grass was recommended for steep, severely eroded areas where potato culture was difficult and yields comparatively low. It was also

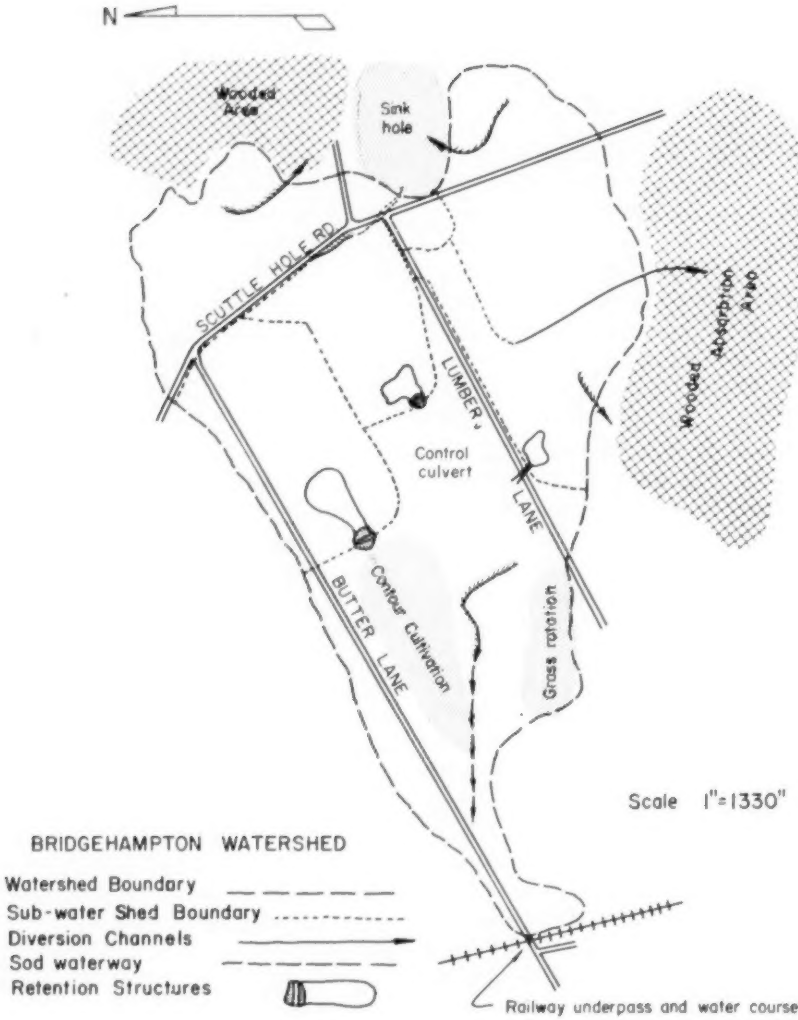


Figure 17. Map of Bridgehampton watershed showing proposed erosion- and flood-control measures

recommended that the rye cover crop should be topdressed with additional nitrogen to encourage rapid growth and better soil cover over winter which in turn should reduce the depth of freezing and the amount of erosion.

Secondly, engineering practices were considered that would divert a part of the runoff into adjacent wooded areas with a rapid infiltration rate. Four possible sites were selected where diversion channels could be built with a minimum interference with tillage practices. Two of these diversion channels were planned to follow the approximate contour of the land. The third was on a common farm boundary and involved several fairly deep cuts and fills to secure a uniform grade. The fourth diversion was planned to carry surface water along a hard-surface road in an open channel, through a road culvert, thence to a natural "kettle hole." In total, these diversion channels would control the runoff from 185 acres of the watershed and reduce the possibilities of damage farther downstream.

Since only a part of the runoff could be controlled economically by these two methods, the third approach included the selection of sites and the design of three retention dams. These sites were in rather steep-sided draws not used for cultivated crops. They were designed to hold approximately 3 inches of water from each acre above them, with provision for a gradual release of the water. The purpose of the retention structure is to reduce the peak flow to the extent that it could be handled farther down slope by a sod outlet and existing highway bridges.

To establish a plan of this scope requires close cooperation of adjacent landowners in obtaining easements and rights-of-way, as well as an equitable assessment of construction and maintenance costs. Cooperation is also needed between highway officials and landowners in the construction of road ditches, culverts and the location of mutually agreeable discharge sites.

Seeding, management, and maintenance of water-control structures

Evidence indicates that any structures built to divert or retard runoff waters on Long Island will require constant maintenance and protection if they are to remain effective. Even with good management of the cropland, silt will accumulate in structures that are designed to reduce the velocity of flow. As previously mentioned, retention dams and seepage pits need to be cleaned frequently. Spillways and outlets need to be seeded to protective grasses and should be fertilized to maintain vigor and complete ground cover. Neglect of these important points can lead to a greater potential damage than might occur without the structures.

Control of Wind Erosion

Modern fertilizing practices, equipment, and irrigation make it profitable to clear and use land not recently cropped. To the extent that natural windbreaks are destroyed, this clearing is unfortunate. As previously noted, wind velocities are high and at certain seasons there is considerable wind erosion. This may be most serious in April after cover crops have been plowed under and before plants have made sufficient growth to protect the soil. At such times dust storms are a menace to traffic and a source of annoyance. On several occasions urban dwellers have sought to obtain court injunctions that would compel farmers to keep soil under cover during that period. Following hard blows soil may be piled in the lee of buildings and fences to a depth of several feet, which indicates that a very considerable amount of soil and fertility has been lost from the affected fields. Tender plants may be broken or damaged by the force of the wind. Shifting sand dunes, although they are usually not found on agricultural land, are also a source of damage in that they are a nuisance and a menace to adjacent property.

Control of wind erosion is simple in a grass country but may be difficult where row crops are produced. Winter cover crops afford protection during the months when they are on the land. (Rye is the most common winter cover and in many instances is the most satisfactory. However, rye-grass is preferable on land that is in vegetables that are harvested without disturbing the soil.) Trees along property and field boundaries reduce wind velocities and so should be kept where practical. Temporary windbreaks, made of snow fence or similar material, may be justified to protect tender plants.

Trash cultivation, whereby cover crops are worked into the soil instead of plowed under, is effective and may be warranted where wind erosion is severe. Roughing the surface or plowing furrows at right angles to the wind may afford some temporary relief. If irrigation equipment is available, the soil may be wet down and thus prevent wind erosion.

Rapid movement of sand dunes may be reduced by snow fences and other temporary windbreaks. The Vermont Agricultural Experiment Station has reported considerable success in revegetating sand blows by seeding weeping lovegrass *(eragrostis curvula)* when liberal amounts of fertilizer and lime were used[11]. Weeping lovegrass is a rapid vigorous-growing perennial with an extensive root system. Although it may winterkill, this is not serious because, with adequate fertility, this grass produces abundant seed which reestablishes the stand.

Other grasses that give promising

[11]Revegetation of sand blows in Vermont. By Joseph B. Kelly, A. R. Midgley, and K. E. Varney. Vermont Agr. Exp. Sta. Bul. 542. 1948.

Figure 18. A windbreak of mixed trees, shrubs, and vines. Such obstacles to wind movement on field and property lines afford protection in proportion to their height, density, and frequency

Figure 19. Wind has nearly covered this snowfence and brush with sand. Anything that checks the velocity of wind promotes deposition and stabilization

results are: false cheegrass, sea lyme, beach grass, and American dunegrass. The disadvantage of these grasses is that they must be planted from rootstocks which requires a considerable amount of expense and labor. In some instances, however, this may be justified. Native vegetation, such as beach pea, partridge pea and blue lupine, have been observed growing on sand dunes but commercial sources of seed are usually not available.

It should be recognized that any attempt to establish vegetation on sand dunes will probably meet with failure if adequate amounts of lime and fertilizer are not applied. An initial application of at least 1 ton of lime and 300 pounds of fertilizer per acre is necessary and should be followed by annual topdressing of the same amount. A 10-10-10 fertilizer should be satisfactory.

Control of Wave Erosion

Approximately 370 miles of shore line are exposed to erosion from wave action on Long Island. The area affected has a high relative value for residence and recreation purposes. Shore erosion represents a serious loss to these interests as well as to agriculture. Since there is no bedrock in the shoreline on Long Island and since the shore material is composed mostly of sand and gravel, wave action causes rapid erosion and shifts in the shore contours. Many low-cost methods of shore protection have been tried in the past, such as rock jetties, piling, and masonry sea

Figure 20. Beach grass effectively holds sand in place. Adequate vegetative control on sands usually requires fertilization

Figure 21. Shore erosion along Long Island Sound after hurricane in September 1944. A board barrier by the posts in the foreground, steps up the bank, and part of the cottage were destroyed as nearly 40 feet of shoreline was cut away by waves during this one storm

walls, but most of them yield to the great forces that are set up by wind and water. Not only must these structures resist the direct pressure of the waves but they must also be built to withstand back pressures created by saturated soil and must have a deep footing to prevent sliding or forward tipping of the wall.

The face of modern sea walls is usually designed with a curved surface to deflect a part of the direct wave force. The surface may be convex, to deflect the waves upward and over the shore line where localized flooding can be tolerated. The surface may be concave to deflect the waves upward and in the direction of the main body of water. Other methods of shore protection include tetrapods, weighing from 10 to 15 tons, which break the force of the waves; revetments, which rest upon, and are supported by, the earth behind them; and groins which extend into the water at some angle to the shore line to stabilize the lateral movement of sands. In order to have some degree of permanence, these structures must be rugged. Their cost is usually beyond the financial limits of the individual landowner and, in most cases, the effectiveness of a particular project depends upon a broad area of protection determined by the shape of the shore line and the direction of water currents and winds.

Figure 22. Large stone or tetrapods for shore protection

Figure 23. Groins or deflectors extend into the water at some angle to the shoreline to stabilize the lateral movement of sand

REMEDIAL ACTION

Recognition and understanding of a problem are the first steps toward its solution. This bulletin, which presents the overall erosion problem on Long Island, may help to provide such understanding. Obviously a bulletin of this nature is limited to a general discussion and cannot supply specific answers to problems on individual fields. Other bulletins are available that supply more detailed information on some of the treatments and control measures that have been suggested. Any recommendation must, however, be modified to fit conditions on individual fields and farms. Hence there is no substitute for on-site analysis and planning.

If problems are at all complex, which is usually the case, most land owners feel they need help to solve them. Such help is available through the provisions of a law that was passed in 1940 by the New York State Legislature. This law permits any county to form a soil conservation district to help farmers control erosion and to make better use of soil and water resources. Each district is governed by five local directors who are solely responsible to the people of the county. Technical help is provided and, in some instances, heavy earth-moving equipment is made available at reasonable cost. To date 45 of the 56 agricultural counties within the State have formed districts.

Each land owner who requests assistance from a district is provided with a soil conservation map of his farm. These maps are prepared by soil scientists who go over the land and record soil, slope, and erosion conditions on aerial photos. They are an inventory of soil and water resources and as such are the basis for any long term farm program.

Land-use capability maps are next prepared which through colors interpret the information contained in the conservation survey maps. Technicians then help the farmer prepare a conservation farm plan that shows what kinds of protective measures are needed and where they should be located. Hence each farm plan is "tailor made" for the land in question and represents the owner's wishes as well as the soil situation. Measures are then established as rapidly as the farmer desires with the district supplying such technical help as may be needed.

Financial aid on a cost-sharing basis to establish certain erosion-control and conservation practices may be available through county agricultural conservation programs.

To summarize: Remedial action must be preceded by an understanding of the problem. Then there must be a desire and an intent to do something about it. If and when people understand the erosion problem, and want to do something about it, they may well consider organization of a soil conservation district.

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